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Frontiers in Physical Science

William R. Savage
University of Iowa

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WILLIAM R. SAVAGE
The University of Iowa

With the fast pace and rapid development of physical science, it is possible for the student to believe that no new problems remain which will require his attention. One may come to the conclusion that no challenging problems remain or that the challenges of today will be solved tomorrow. It is important to regard physical science as a human endeavor with a future and broad scope. The frontiers exist and are easily described and recognized in all areas.

Physical science can have both a broad and narrow scope. In this discussion I restrict physical science to those investigations which, generally speaking, involve physics and chemistry rather than biology, geology, and zoology, for example. Even this definition would lead to more topics than one can treat easily in a short discussion. Therefore, we will further restrict our area of physical science to a few special topics as we describe some of the frontiers.

Space Physics

If we used only size as the criterion, by far the largest frontier is in the area of space sciences. The areas of new work are those which treat the far-distant objects within such topics as galactic structure, astrophysics, and studies of interstellar matter. Other topics would include the extended atmosphere of the earth and its radiation zones and the fine structure of the ionized layers of our atmosphere. A study of our moon and solar system makes the next area nearest us in distance also one of great size and importance. With regard to our earth we have a fairly good notion of the earth's magnetic field, the interaction of the earth with the solar proton wind, and the resulting trapping of ionized partcles. As is true in all branches of science, the first measurements were essentially simple and the conclusions drawn from them general. However, one should not assume that modern space physics is an easy venture, yet it is in fact challenging and requires the support of a large-scale technological complex. The early experiments dealt with the general aspects of the phenomena while space science is engrossed now in detailed observations. A specific problem of current interest is in the area of whistler radio noise which can be received with the proper modifications to standard radios. They represent the dispersed signal from lightning charges in the atmosphere. Earth orbiting satellites can detect them and related signals as well as the ground based installation. The speed with which the various radio waves, which are emitted by the lightning bolt, pass through the ionized atmos-

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phere and trapped radiation zones gives information about the type of particles and their interactions. The radio wave impulse is dispersed by the ionized atmosphere so that the different frequencies arrive at the receiver at different times. When the radio signals are fed to a loud speaker, the frequency range is just right to give a sound which is like a whistle.

Solar Physics

Other areas of space studies involve the sun as the source of the proton wind. Changes in the appearance of the sun have been associated for years with changes on the earth such as weather. Only now are we beginning to see the detailed mechanism behind the interaction of the solar wind with the top of the atmosphere. Techniques such as X-ray and radiotelescopic investigations are just beginning to be used effectively in studying the star nearest us, the sun. Soon we may set foot on the moon and perhaps a planet or two. Such projects are obvious new frontiers for physical research.

Laser Research

An area of research that has attracted the imagination of the general public has been the study of light and the laser. Very quickly after the discovery of the principle for the operation of lasers, the actual devices were being manufactured and used in research and technology. From the very beginning the laser has been a research tool waiting for uses. The main applications of a laser have depended upon the very high radiant energy per unit area of the beam. Devices exist for welding fine wires, for drilling hard substances such as diamonds, and for performing delicate surgery on the eye or even operating on individual cells. In the case of the laser as well as in other areas, the rapid transfer from the science laboratory to commercial devices has left a large number of basic problems in an unsolved condition. At the present time little use is made in research or application of the fact that the light is coherent. The coherency of light is a statement that all the individual waves of the radiation are in phase; that is, in step with each other. This should give rise to strong coupling effects at the frequency of the light. It would seem that in the laser we now have a research tool waiting for application to the optical behavior of materials.

Superconductivity

One of the most spectacular changes in a property of a substance is the fact that a limited number of metals lose all their electrical resistance when they are cooled to sufficiently low temperature. The potential uses of such substances are many and vary from electrical power transmission cables to computer memories. The most successful commercial application is in the area of very high field strength electromagnets. The interior of superconductors behaves in exactly the right way to give zero magnetic induction for all fields lower than a critical field. This property is important in the development of these very high-strength magnets. For reasons not yet understood the temperature at which this change occurs is lower than 20 Kelvin for all presently known superconductors. Currently scientists are searching for metallic elements which never exhibit superconductivity.

Semiconductivity

We are all familiar with the term solid state electronics as related to hi-fi and TV. Basically, the term applies to the large number of electrical circuit elements such as transistors which are used to regulate, detect, and control the flow of electrons in solids. With solids we have a fairly large number of elements from which to select electrical conductors. When these are formed into compounds and alloys, the variety of types of electrical resistive behavior as well as the total number of materials which conduct electric current increases. Then when a trace of impurity is added, the effects may be slight or extremely pronounced as is true for semiconductors. The choice of research materials on this frontier alone is enough to keep the research worker in the laboratory for quite a long time.

Magnetism

An additional problem is the case of magnetic behavior of materials. Most students have encountered ferromagnetism in some form. Other forms of magnetic behavior of solids are known. The aim of the solid state physicist is to describe the behavior of solids from an atomic and molecular point of view. The problem in the case of magnetism is to account for the ways in which electrons in a solid interact with each other as well as interacting in the atomic cores. As an aid in studying magnetic interactions, we again can make use of the elements and their properties. By using the interactions between the molecules and atoms, we can study their effects. We then prepare alloys and compounds in a way which will permit some control or variation of the properties being investigated. If one can predict the behavior on the basis of the atoms and molecules that form the material, science could provide technology with exactly the materials needed for magnetic applications.

So far our discussion has treated the frontier from the point of view of the unsolved problems. The actual frontier is in the attitude of the research worker. The problems are there to be solved and may remain or still others will exist in the future. There is only one way to react to the feeling that physical science presents no challenge, and it is to find the excitement at the frontier. Also, one must not confine the excitement to the specific task, but it should be shared in all studies at all levels. It is important that everyone be reminded that learning about new areas, fixing the inexact nature of our understanding, and looking for new knowledge are more important than the acquisition of a collection of facts. The growth of technology is synonymous with the exploration of new frontiers of science. One may not find the direct connection of space physics, lasers, magnetism, astrophysics, and semiconductors with the technology of today, but the technology of tomorrow will surely be founded on the science of today.

We must pay our debt to the science of a bygone era and its contribution to today's work by contributing a just portion of our effort to the physical science frontiers of today.